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Endovascular repair of extracranial carotid artery dissection: current status and level of evidence

Donas, K P ; Mayer, D ; Guber, I ; Baumgartner, R ; Genoni, M ; Lachat, Mario

Abstract: PURPOSE: To provide evidence for the endovascular repair of patients with extracranial carotid artery dissection. MATERIALS AND METHODS: A comprehensive literature review was performed whereby all studies that reported on the results of endoluminal repair of extracranial carotid artery dissection and provided information about primary technical and clinical success were identified. The Pubmed, Embase, and Medline databases were searched between January 1997 and February 2008 by two independent observers by using combinations of search terms "endovascular repair," "extracranial carotid artery," and "carotid dissection." RESULTS: After studies were selected according to the given criteria, 13 studies were included in our statistical analysis. The number of reported patients was 62, with a total of 63 extracranial carotid artery dissections. The mean patient age was 43.3 years. The mean follow-up period was 15.7 months +/- 8.7. Various causes were responsible for the disease, including a blunt neck injury in 28 patients (45%), spontaneous dissection in 21 (37%), and iatrogenic trauma during invasive radiologic procedure in 17.7% patients. The technical success rate was 100% (63 of 63 procedures). The primary and 1-year patency rate of the stents and/or stent-grafts was 100%. The overall major adverse cardiovascular events rate was 11% (seven strokes). The total follow-up mortality rate was 0%. CONCLUSIONS: The current status of the reported cases in the literature regarding the treatment of carotid artery dissection by means of stent placement shows excellent early and 1-year patency rates and a low major adverse cardiovascular event rate. However, further evaluation is necessary to draw robust conclusions.

DOI: https://doi.org/10.1016/j.jvir.2008.08.025

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Donas, K P; Mayer, D; Guber, I; Baumgartner, R; Genoni, M; Lachat, Mario (2008). Endovascular repair of extracranial carotid artery dissection: current status and level of evidence. Journal of Vascular and Interventional Radiology, 19(12):1693-1698.
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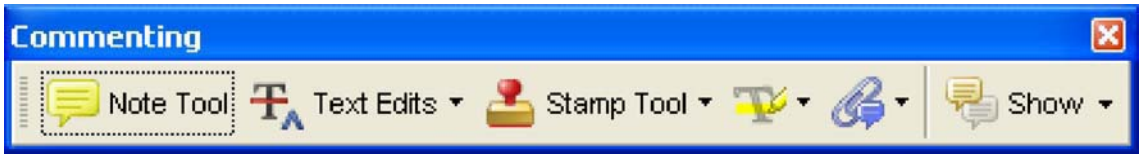

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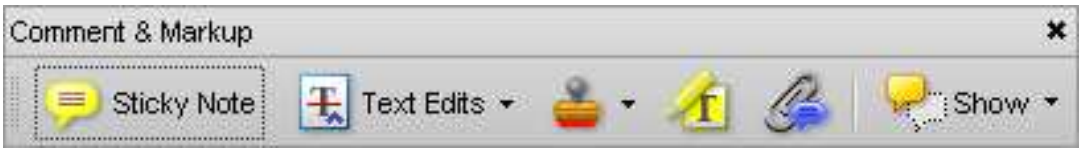

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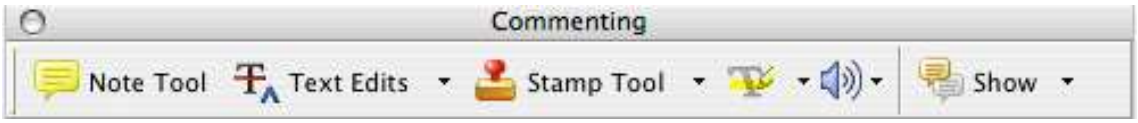

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Clinical Studies

Endovascular Repair of Extracranial Carotid Artery Dissection: Current Status and Level of Evidence

Konstantinos P. Donas, MD, Dieter Mayer, MD, Ivo Guber, MD, Ralf Baumgartner, MD, Michele Genoni, MD, and Mario Lachat, MD

PURPOSE: To provide evidence for the endovascular repair of patients with extracranial carotid artery dissection.

MATERIALS AND METHODS: A comprehensive literature review was performed whereby all studies that reported on the results of endoluminal repair of extracranial carotid artery dissection and provided information about primary technical and clinical success were identified. The Pubmed, Embase, and Medline databases were searched between January 1997 and February 2008 by two independent observers by using combinations of search terms "endovascular repair," "extracranial carotid artery," and "carotid dissection."

RESULTS: After studies were selected according to the given criteria, 13 studies were included in our statistical analysis. The number of reported patients was 62, with a total of 63 extracranial carotid artery dissections. The mean patient age was 43.3 years. The mean follow-up period was 15.7 months ± 8.7. Various causes were responsible for the disease, including a blunt neck injury in 28 patients (45%), spontaneous dissection in 21 (37%), and iatrogenic trauma during invasive radiologic procedure in 17.7% patients. The technical success rate was 100% (63 of 63 procedures). The primary and 1-year patency rate of the stents and/or stent-grafts was 100%. The overall major adverse cardiovascular events rate was 11% (seven strokes). The total follow-up mortality rate was 0%.

CONCLUSIONS: The current status of the reported cases in the literature regarding the treatment of carotid artery dissection by means of stent placement shows excellent early and 1-year patency rates and a low major adverse cardiovascular event rate. However, further evaluation is necessary to draw robust conclusions.

J Vasc Interv Radiol 2008; xx:xxx

THE first case of spontaneous dissection of the carotid artery was described by Jentzer (1) in 1954. The average incidence rate is 2.6–3.0 per 100,000 population (2), and it is an important cause of stroke in young adults (3). The actual incidence may be higher because many cases are asymptomatic or show only minor transient neurologic symptoms and remain undiagnosed.

The main mechanism of ischemic stroke in carotid artery dissection is thromboembolism (4). Consistent with these findings, antithrombotic treatment with anticoagulatives or aspirin and frequent control of the diseased artery with imaging remains the first-line treatment option (4). Nevertheless, several medical conditions—such as the recurrence of neurologic deficits despite appropriate antithrombotic therapy, hemodynamic brain ischemia, contraindication of antiplatelet medication because of the risk of bleeding, and the expansion of concomitant pseudoaneurysms with neurologic symptomatology—justify an alternative therapeutic approach to achieve a sufficient restoration of the vessel lumen.

Because of the unfavorable results of surgery (5), which are linked to substantial difficulties in preparation of the dissected carotid artery and cranial nerve injury, endovascular strategies are increasingly applied, with corresponding reported outcomes encouraging (6–18).

We performed a literature review and analysis to determine the outcome and safety of endovascular repair of acute extracranial carotid artery dissection.

MATERIALS AND METHODS

Search Strategy

An extensive search of literature published between January 1997 and February 2008 was performed by using PubMed, Embase, and Medline

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None of the authors have identified a conflict of interest.

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DOI: 10.1016/j.jvir.2008.08.025

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databases with keywords "endovascular repair," "extracranial carotid artery," and "carotid dissection." In addition, reference lists of all included articles were examined for further relevant references. All studies were independently assessed by two reviewers for inclusion and exclusion criteria, and the full text of these studies was retrieved.

Eligibility of the Studies

Studies were included if the following criteria were fulfilled: (*a*) endoluminal repair of the carotid artery dissection was the intended repair strategy, (*b*) there had been a minimum follow-up period of 6 months, and (*c*) the diagnosis of extracranial carotid artery dissection and brain ischemia had been performed with contrast medium–enhanced computed tomography (CT), magnetic resonance (MR) imaging, or angiography. The diagnosis of carotid artery dissection was based on the detection of a mural hematoma in the cervical carotid artery. Angiographic diagnosis was based on detection of a flame-shaped occlusion, string sign, segmental stenosis beginning distal to the carotid bulb, or a dissecting aneurysm. In addition, in the presence of occlusion of the cervical carotid artery at angiography, studies were included if MR imaging detection of a mural hematoma was needed for the diagnosis of carotid artery dissection, (*d*) at least one of the basic outcome criteria (ie, neurologic morbidity, stent patency, endoprosthesis-related complications, and total mortality rate) was stated, (*e*) endoluminal repair of the carotid dissection performed during intraarterial thrombolysis was excluded, and (*f*) no cases involved the intracranial carotid artery either exclusively or by extension.

Data Extraction and Analysis

For each study, the following data were extracted and analyzed by two independent reviewers: the number of patients and their sex and mean age (in years); initial symptoms at clinical examination; primary technical success; 30-day clinical success; stent-graft design; mean follow-up period (in months); neurologic morbidity; major adverse cardiovascular events, including myocardial infarction, stroke, and death; stent and/or stent-graft patency and endoprosthesis-related complications; repeat interventions; and total follow-up mortality**.** Fulfilment of all of these particular parameters was an obligatory condition of the inclusion of the particular patient group in the meta-analysis. In cases of divergent data extraction results between the two observers, articles were reviewed again and data extracted in consensus. The clinical success of the technique was defined as technical success and as clinical success was defined in the absence of transient ischemic attacks, local symptoms and signs and ischemic events occurring within 30 days after the intervention other adverse events (eg, inguinal bleeding, aneurysms, bleeding with anemia).

Patient Selection Criteria

Patients with acute carotid artery dissection treated with stent and/or stent-graft–supported angioplasty were selected on the basis of (*a*) the failure of conservative treatment and drug administration with persistent neurologic deficits; (*b*) ischemic or thromboembolic symptoms; (*c*) contraindication to anticoagulation and antiplatelet therapy due to the presence of a large infarct with associated mass effect, hemorrhagic transformation of the infarcted area, and an intracranial aneurysm; (*d*) traumatic dissections with high-degree stenosis; (*e*) expansion of concomitant pseudoaneurysms in the extracranial carotid artery with neurologic deficits; (*f*) severe reduction in cerebral blood flow; and (*g*) contraindication of open repair in the patients.

Distribution of the Studies according to Specialty

The included studies were published from different clinical departments such as the division of vascular surgery ($n = 3$), neurosurgery ($n = 3$), general surgery ($n = 2$), interventional radiology ($n = 2$), and neurology ($n = 1$). The inhomogeneous medical background is demonstrated in the characterization of the postoperative neurologic events. To overcome this medical impasse, central neurologic symptoms were defined as amaurosis fugax, transient ischemic attack, and stroke and local neurologic symptoms and signs were defined as unilateral headache, Horner syndrome, or palsy of cranial nerves.

Statistical Analysis

All numeric values are stated as means ± standard deviations, with minimum and maximum values in parentheses. All percentages were calculated by using the total number of reported patients as 100% for each parameter.

RESULTS

Our electronic literature search resulted in 27 studies. After additional search by hand and selection in accordance with the inclusion criteria, 13 studies were included in our statistical analysis (7–18). Detailed data from the eligible studies are provided in **Table 1**, and data from the excluded articles (5,19–31) are given in **Table 2**. Studies were excluded if there was conservative or surgical treatment of acute carotid dissection, involvement of the intracranial segment of the carotid artery or vertebral artery, follow-up of less than 6 months, and no report of clinical outcomes.

The eligible studies included 62 patients, 34 of whom were men (55%). The mean patient age was 43.3 years ± 8.7 (range, 17–80 years; median, 45.3 years). In 39 of the 62 patients (63%), the presumed cause of the carotid dissection was trauma; in 11 of those patients (18%), iatrogenic dissection occurred during an invasive radiologic procedure. In the remaining 23 patients (37%), dissections showed spontaneous development. The mean follow-up period was 15.7 months ± 8.7 (range, 5.6–38.3 months; median, 13.5 months).

The presenting characteristics for the patients with symptomatic carotid dissection are shown in **Table 3**. The technical success rate was 100% (63 of 63 procedures). The primary and 1-year patency rate of the stent and/or stent-grafts was 100%. During the follow-up period, one asymptomatic in-stent de novo restenosis (1.5%) of the dissected carotid was noted 22 months after the initial successful intervention. This was treated conservatively, and the patient remained without neurologic deficits. Furthermore, 54 of the 62 patients (87%) remained free of new or

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Table 1
Studies of Endovascular Treatment of Extracranial Carotid Artery Dissection Included in the Review Analysis

Author	Year	No. of Patients	Mean Follow-up (mo)	In-Stent de novo Stenosis or Thrombosis	Speciality of the Authors*	Cause of Dissection†
Schulte et al (18)	2008	7	24.4	1	VS	T
Cohen et al (16)	2005	10	16	0	NS	T
Biggs et al (11)	2004	1	19	0	GS	S
Assadian et al (12)	2004	6	38.3	0	VS	T+S
Malek et al (7)	2000	10	16.5	0	GS	T+S
Edgell et al (8)	2005	7	14	0	N	S
Cohen et al (17)	2003	3	12	0	NS	S
Liu et al (6)	1999	7	20.2	0	GS	T+S
Duke et al (10)	1997	7	5.6	0	NS	T
Bejjani et al (13)	1999	5	6	0	IR	T+S
Matsuura et al (9)	1997	1	12	0	VS	T
Fanelli et al (15)	2004	1	13	0	IR	T
Biondi et al (14)	2005	1	8	0	IR	S

* GS = general surgery, IR = interventional radiology, N = neurology, NS = neurosurgery, VS = vascular surgery.
† S = spontaneous, T = trauma.

Table 2
Excluded Studies of Endovascular Treatment of Extracranial Carotid Artery Dissection

Study	No. of Patients	Exclusion Criteria			
		Conservative Treatment or Surgery	Follow-up <6 mo	Dissection in the Intracranial Segment of the Carotid or Vertebral Artery	Absence of the Outcome Criteria
Wu et al (19)	3	X			
Jariwala et al (20)	1	X			
Treiman et al (21)	24	X			
Müller et al (4)	48	X			
Bassi et al (22)	49		X		
Dziewas et al (23)	126	X		X	
Townend et al (24)	2	X			
Lee and Jensen (25)	1	X		X	X
Chiche et al (26)	10				
Sagoh et al (27)	1			X	
Chaves et al (28)	10			X	
Pace et al (29)	2	X			
Mas et al (30)	13	X			
Lin et al (31)	5			X	

recurrent ischemic symptoms after the endovascular approach. Seven of the 62 patients (11%) experienced an early (<30 days) central neurologic event, including an ischemic stroke in six patients (9.7%) and a transient ischemic attack in one patient (1.6%). Subsequent clinical symptoms such as hemiparesis ($n = 2$), persistent dysphagia ($n = 1$), residual hand weakness ($n = 1$), hemorrhagic conversion with recovery ($n = 1$), and partial expressive aphasia ($n = 1$) occurred due to the cerebral infarction. Another patient had a stroke in the territory contralateral to the carotid occlusion after hypotensive uterine hemorrhage occurred 8 months after endovascular repair of the carotid dissection.

No disease-related death was noted in the included patients after the primary successful endovascular intervention. Thus, the early (<30 days) postprocedural major cardiovascular events rate was 9.7% (six strokes). The overall postprocedural major cardiovascular events rate was 11% (seven strokes). No patient experienced myocardial infarction, contrast medium–induced renal insufficiency, or a minor complication such as relevant groin hematoma.

Patient demographics and results are shown in **Table 4**. Four of the 13 included studies report on a spontaneous cause of the dissection. Five studies describe the outcome of the endovascular strategies in carotid dissection only of traumatic origin. The other articles analyze mixed cases of spontaneous and traumatic cause without separating the outcomes for the spontaneous and traumatic cases. Therefore, it was not possi-

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Table 3
Clinical Findings in Patients with Neurologic Events caused by Carotid Dissection

Symptoms	No. of Patients (n = 62)
Central ischemic symptoms	6 (9.6)
Stroke	
Transient ischemic attack and/or amaurosis fugax	9 (14)
Local symptoms and signs on the side of the carotid dissection	
Headache, hemicrania	12 (19)
Face or neck pain	12 (19)
Horner syndrome	11 (25.8)
Tinnitus	4 (6.5)

Note.—Numbers in parentheses are percentages.

ble for the investigators of these particular articles to draw any conclusion for each subgroup.

All patients treated with endoluminal techniques experienced complete recovery of the preoperative neurologic deficits, with a patency rate of 100%. One patient had hemorrhagic conversion of a large infarct 13 days after the intervention, with complete alleviation of the symptoms. This patient was living independently without new neurologic deficits 2 years after the intervention. Conversely, two of the 22 patients with traumatic dissections (9%) had evidence of cerebral infarction postoperatively. All stents and/or stent-grafts were patent. One asymptomatic relevant stenosis (>70%) of the internal carotid artery was noted 22 months after the intervention.

The most commonly used stent and/or stent-graft designs are shown in the **Figure**.

DISCUSSION

The treatment of extracranial carotid artery dissection with anticoagulation has been proved to be effective, with an approximate 50%–70% arterial recanalization rate and a 10% risk of late neurologic deficits (32–39). However, the high incidence of stroke within 30 days of the dissection (21%–41%) and the approximately 20% mortality rate make a compelling argument for alternative, more successful treatment strategies for overcoming these medical impasses (37).

Surgical repair of this clinical entity often requires extensive and difficult exposure until the base of the skull which is linked to a 68 % perioperative recurrent stroke rate and cranial nerve injury, and to fracture of the styloid at its base (5). Surgery was performed in patients who had not responded to anticoagulant therapy or those who had developed an aneurysm formation at the distal end of the dissection near the skull base (5). In fact, some authors reported the aneurysm dilatation combined with a proximal high-grade stenosis of at least 80% (5).

Conversely, endoluminal repair of carotid dissection would seem a valuable treatment option in overcoming the several drawbacks of the other two therapy options, that is, anticoagulation and surgery (18). Additional advantages of endovascular strategies in diagnosis and therapy enable reliable identification of true and false lumens and allow a sufficient restoration of the vessel lumen with use of microcatheter techniques (12). Moreover, the endovascular approach, also using coil embolization, has proved effective for the simultaneous treatment of any coexistent pseudoaneurysmal dilatations while circumventing the need for cross-clamping, which would not have been tolerated in most patients with poor collateral, contralateral significant involvement, and serious concomitant diseases (10).

In addition, another benefit of stent-assisted angioplasty is avoidance of the need for shunt implantation, which is also associated with a high risk of extension of the dissection with consecutive neurologic events (18).

The literature, however, provides scant information with regard to the immediate and long-term results of endovascular repair of carotid dissection, mostly in the form of case reports and small patient series. Therefore, this literature analysis aims to demonstrate the results of the published series under inclusion criteria and attempts to draw several conclusions about the endovascular outcomes.

The use of endovascular techniques in the eligible studies led to a complete neurologic recovery or the absence of new ischemic complications in 54 of the 62 patients (87%). The technical success rate was 100% (63 of 63 procedures). The long-term mortality rate was 0% and the patency rate 100%, with only one asymptomatic in-stent de novo restenosis, which was treated conservatively. In particular, the subgroup analysis of the patients with symptomatic spontaneous carotid dissections showed excellent midterm results (2 years), with no evidence of postinterventional neurologic events and a 100% patency rate. Of the 22 patients with traumatic dissections, two (9%) experienced postprocedural neurologic deficits (two strokes) and one had asymptomatic high-grade stenosis of the internal carotid artery.

In summary, seven patients (11%) experienced an early postprocedural neurologic event (<30 days). A total of eight patients (13%) had a postprocedural neurologic event (seven patients had stroke, one patient had a transient ischemic attack). Narrowing of the carotid artery caused by dissection seems to be an important potential embolic source. Therefore, deployment of cerebral protection devices during the intervention and extended radiologic imaging appear to be reasonable recommendations for achieving a lower neurologic morbidity over a longer follow-up period. However, most of the reported studies (11 of 13) did not confront the dilemma of cerebral protection device use during the intervention to prevent neurologic deficits.

The adjunctive use of anticoagulative or antiplatelet therapy after the placement of the stent devices seems to be beneficial for preventing thrombus formation on the metal surface of the endograft before endothelialization. The suggested medication is the combination of aspirin (100 mg per day) and Clopidogrel (75 mg per day for 4–6 weeks after the procedure and then administration of only aspirin [100 mg per day] for life) (18).

The present review analysis, however, has some clear limitations—such as an inhomogeneity of the published cases conducted by different medical specialities (eg, vascular surgeons, neurosurgeons, interventional radiologists, and neurologists). This divergence is clearly demonstrated in the description of postoperatively occurring neurologic events, and, despite our clear definitions, definitive conclusions about

Table 4
Comparison between Spontaneous and Traumatic Carotid Dissection

Cause of Carotid Dissection	No. of Patients	No. of Studies*	Mean Follow-up (mo)	Central Neurologic Deficit†	Local Signs or Asymptomatic‡	Complete Recovery§	Permanent Neurologic Deficit
Spontaneous	12	4	12.8	8/12	4/12	12/12	0
Trauma	22	5	14	7/22	15/22	20/22	2/22
Spontaneous and trauma	28	4	20.2	0/28	28/28	22/28	6/28
Total	62	13	15.7	15/62	47/62	54/62	8/62

* Number of studies regarding the cause of the dissection.
† Central neurologic deficits = transient ischemic attack and stroke.
‡ Local neurologic deficits = Horner syndrome, tinnitus, hemicrania, facial or neck pain, and headache.
§ Complete recovery = no clinical neurologic sign of sequela and no radiologic evidence of cerebral or retinal ischemia.

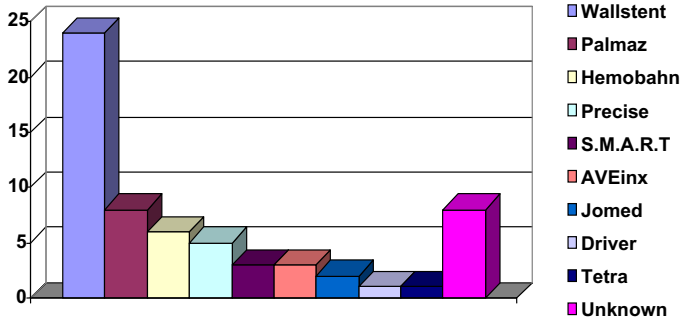

Chart shows stent and/or stent-graft designs used in the treatment of acute carotid artery dissection.

the postoperative neurologic status are conditionally accepted.

Moreover, it may be important to estimate the neurologic clinical status of the patients in information about the severity of the stroke by using the Rankin scale scores. This is an important parameter considering that the 9.7% postprocedural stroke rate is high for complications and surpasses that occurring with antithrombotic treatment. Finally, it is important to mention possible bias when reporting novel techniques, tending to overestimate the benefits of that technique when considered in aggregate.

In conclusion, the findings of the present review analysis using stent- or stent-graft–supported angioplasty in patients with extracranial carotid artery dissection and failure of other treatment modalities are promising. Nevertheless, further evaluation with a large number of patients and long follow-up is necessary to provide evidence and draw robust conclusions.

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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES 1

AQ19— please give manufacturer and location for all trade names.

AQ20— add of ″No. of Patients″ correct?

AQ21— add of ″mean″ correct?

AQ22— edit of table ok?

AQ23— add of n = 62 correct? should number below add to 62?

AQ24— : 11/62 = 18% – please clarify how you got this percentage.

AQ25— add a new head ″Outcome″ (or something like that) to span over ″complete recovery″ and ″permanent neurologic deficit″?

AQ1— are these reviewers authors? if so, please provide initials.

AQ2— add of ″studies were included if″ ok? if not, please clarify.

AQ3— should this be ″(d)″?

AQ4— this was changed from a ″5″ – are we missing a ″4″ from original?

AQ5— please clarify this sentence.

AQ6— add of ″(standard deviations″ correct?

AQ7— there are only 12 studies listed here. 6–18 ?

AQ8— percentages have been rounded per AMA and journal style (throughout)

AQ9— add of ″the investigators of″ ok?

AQ10— please clarify this sentence.

AQ11— poor collateral circulation or something like that?

AQ12— auth

AQ13— please clarify this sentence. also, please provide raw data for percentage.

AQ14— edit of sentence ok? if not, please clarify.

AQ15— ; edit of previous 2 sentences ok? if not, please clarify.

AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES **2**

AQ16— ; is this a trade name? if so, please provide manufacturer and location. is there a generic name we could use instead?

AQ17— edit of sentence ok?

AQ18— has this been published yet? if so, please provide volume number and pages.